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Wind Data from Memphis Airport

Office of Communications,
Navigation and
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Washington, D.C. 20591

Research and Special Programs Administration
John A. Volpe National Transportation Systems Center
Cambridge, MA 02142-1093

Final Report
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David Burnham* and Steve Abramson

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13. ABSTRACT (Maximum 200 words)

A 1300-foot array of horizontal and vertical single-axis anemometers was installed at the Memphis, TN Airport on 10- and 13-foot poles under the approach to Runway 727. One-minute average measurements were recorded continuously from mid August 1995 through late December 1995. Although the original purpose for the anemometers was to track the lateral position of wake vortices, the measurements also provide a database of wind and turbulence that can be used for other purposes. For example, the crosswind data could be used to evaluate adaptive wake vortex separation systems based on the measured crosswind. This report documents the data formats and database characteristics and provides information on how to obtain a copy of the data.

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PREFACE

One of the long-term goals of the United States Wake Vortex Program is to develop systems that adapt wake-vortex separations to changes in circumstances, such as meteorology, which would affect the risk of a wake-vortex encounter. A number of systems based on crosswind measurements have been developed in the United States, Germany, and elsewhere. The purpose of this report is to provide a wind data set that can be used to evaluate such systems.

The Federal Aviation Administration (FAA) Wake Vortex Program Manager, George C. (Cliff) Hay, has asked the John A. Volpe National Transportation Systems Center (Volpe Center) to make its extensive archives of wake vortex data available in electronic form for wake vortex research. This report is the second in a series that will document available data and make it available on CD ROM to interested parties. The CD ROM can be obtained by contacting the Volpe Center library. The first report provided wind data from Kennedy airport. This report provides similar data from Memphis airport.

The authors would like to acknowledge the support of Leo Jacobs, who helped install and maintain the Kennedy test site, and David Hazen, who managed and validated the data files coming from the site and the surface observations. Both are employees of the System Resources Corporation. Jim Hallock of the Volpe Center reviewed the report and assisted in getting it published.

METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in) = 2.5 centimeters (cm)
1 foot (ft) = 30 centimeters (cm)
1 yard (yd) = 0.9 meter (m)
1 mile (mi) = 1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2) = 6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2) = 0.09 square meter (m^2)
1 square yard (sq yd, yd^2) = 0.8 square meter (m^2)
1 square mile (sq mi, mi^2) = 2.6 square kilometers (km^2)
1 acre = 0.4 hectare (ha) = 4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz) = 28 grams (gm)
1 pound (lb) = .45 kilogram (kg)
1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp) = 5 milliliters (ml)
1 tablespoon (tbsp) = 15 milliliters (ml)
1 fluid ounce (fl oz) = 30 milliliters (ml)
1 cup (c) = 0.24 liter (l)
1 pint (pt) = 0.47 liter (l)
1 quart (qt) = 0.96 liter (l)
1 gallon (gal) = 3.8 liters (l)
1 cubic foot (cu ft, ft^3) = 0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3) = 0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

°C=5/9(°F - 32)

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm) = 0.04 inch (in)
1 centimeter (cm) = 0.4 inch (in)
1 meter (m) = 3.3 feet (ft)
1 meter (m) = 1.1 yards (yd)
1 kilometer (km) = 0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2) = 0.16 square inch (sq in, in^2)
1 square meter (m^2) = 1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2) = 0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2) = 1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gm) = 0.036 ounce (oz)
1 kilogram (kg) = 2.2 pounds (lb)
1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons

VOLUME (APPROXIMATE)

1 milliliter (ml) = 0.03 fluid ounce (fl oz)
1 liter (l) = 2.1 pints (pt)
1 liter (l) = 1.06 quarts (qt)
1 liter (l) = 0.26 gallon (gal)
1 cubic meter (m^3) = 36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3) = 1.3 cubic yards (cu yd, yd^3)

TEMPERATURE (EXACT)

°F=9/5(°C) + 32

QUICK INCH-CENTIMETER LENGTH CONVERSION

INCHES 0 1 2 3 4 5

CENTIMETERS 0 1 2 3 4 5 6 7 8 9 10 11 12 13

QUICK FAHRENHEIT-CELSIUS TEMPERATURE CONVERSION

°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50. SD Catalog No. C13 10286.

Updated 8/1/96

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1. INTRODUCTION

In 1995, the John A. Volpe National Transportation Systems Center (Volpe Center) installed a ground-wind wake vortex tracking system[1] at the Memphis Airport at the Runway 31R approach region. The system had previously been installed at New York's Kennedy Airport[2] from August 1994 through June 1995. The installation consisted[3] of an array of two-axis anemometers (vertical wind and crosswind). The headwind was also measured at the ends of the array. The data collection system operated automatically and generated data files of one-minute averages, with standard deviations, of all anemometers. The wind data collected from August 14, 1995 through December 26, 1995 will be presented in this report. The data collection was continuous during this period; the data collection terminated during the day on December 1995.

The purpose of this report is to make the wind data set available to other researchers. Chapter 2 describes the data collection, and Chapter 3 the data processing. Chapter 3 also presents the headwind and crosswind distributions and the day-by-day data availability for the data set. Chapter 4 describes the databases provided on the available CD ROM; which can be obtained by contacting the Volpe Center Library (617-494-2306).

2. DATA COLLECTION

2.1 DATA DIGITIZATION

2.1.1 Sensor Descriptions

The sensors listed in Table 1 were digitized by five Campbell Scientific data acquisition systems (CSDAS #n, n=1-5). All CSDAS report in low-resolution binary format (two bytes per channel). The CSDAS sample the sensors at 10 Hz and report two-second averages every two seconds. Since the five CSDAS may not be synchronized, the data acquisition system prefixes the second the message was detected (to hundredths of a second) in standard Campbell low resolution format. Since the message channels are scanned every half second, the actual resolution on the message time tags is only 1/2 second (not the 1/18 second resolution of the computer clock). The wind units are meters/second. The aircraft noise units are 0.1 volts.

Table 1. Sensors Recorded

Sensors	Units	Number	Total Channels
Two-Axis Anemometers	m/s	29	58
Three-Axis Anemometers	m/s	2	6
Noise	0.1 volt	2	2
TOTAL		33	66

Table 2. Anemometer Pole Locations

Pole	Elevation (ft)	Distance (ft) from Runway Centerline	Height (ft)	Number Axes
01	+1.9	-650	30	3
02	+0.2	-600	30	2
03	+2.4	-550	30	2
04	+4.0	-500	30	2
05	+4.4	-450	30	2
06	+4.8	-400	30	2
07	+5.0	-350	30	2
08	+4.2	-300	30	2
09	+2.3	-250	30	2
10	-0.1	-200	30	2
11	-2.9	-150	10	2
12	-5.4	-100	10	2
13	-4.8	-75	10	2
14	-4.2	-50	10	2
15	-3.2	-25	10	2
16	-2.4	0	10	2
17	-1.2	25	10	2
18	-1.9	50	10	2
19	-0.0	75	10	2
20	+0.5	100	10	2
21	+0.0	150	10	2
22	+1.5	200	30	2
23	+3.1	250	30	2
24	+3.0	300	30	2
25	+0.8	350	30	3
26	-21.	400	30	2
27	-2.7	450	30	2
28	-2.9	500	30	2
29	-2.6	550	30	2
30	-2.2	600	30	2
31	+2.9	650	30	3

The anemometer poles were installed at the locations given in Table 2. The anemometer array was located 400 feet toward the runway threshold from the middle marker. The elevation of the base of each pole was surveyed and found to vary by ±5 feet relative to a reference elevation of 300 feet. The elevation of the middle marker was +4.7 feet (i.e., 304.7 feet - 300 feet). The terrain sloped down toward the runway; the elevation of the extended runway centerline was -5.9 feet about 800 feet from middle marker. Beyond the middle marker the terrain dropped abruptly, but a large two-story building was located on the runway centerline.

Most of the anemometers were installed at approximately 30-foot height on 19 fiberglass poles. Shorter 10-foot poles were used in the middle of the array to prevent blocking the view of the runway approach lights. To compensate for the lower height, the pole spacing was reduced in the middle of the array. The three-axis anemometers measure crosswind, vertical wind and headwind. The two-axis anemometers measure crosswind and vertical wind. The sign convention is defined with respect to a pilot landing on Runway 27; positive lateral distances and crosswinds are toward the pilot's right hand. The distances from the middle marker are toward the runway.

The aircraft noise sensors were installed near the runway centerline on the anemometer line. The noise detectors consisted of horn-type loudspeakers pointing upward toward the aircraft flight path. The horns were provided with drain holes to eliminate water and were covered with thin plastic to exclude snow. The noise detectors were mounted on the runway side of a large piece of plywood (a plane perpendicular to the flight path) to provide a more abrupt increase in noise when the aircraft passed the anemometer array.

The single-axis propeller anemometers were manufactured by the R. M. Young Company with a current Model No. of 27106R. The four-bladed propellers are made of black polypropylene, have a distance constant of 2.7 meters and a starting speed of 0.5 m/s, and have an approximate cosine wind response. The calibration of each anemometer was checked for nominal response (17.2 m/s per volt).

2.1.2 Parameter Names

Table 3 describes the channel assignment. The alphanumeric names assigned to each sensor are indicated in the channel assignments. The anemometer axes are labeled Cnn, Vnn or Hnn, where nn refers to the pole number and C, V or H refer to crosswind, vertical wind or headwind, respectively. The two aircraft noise sensors are designated ACn. The names of the standard deviation parameters are obtained by prefixing a "T" for turbulence, e.g., TVnn. Note that, according to Monin-Obukhof similarity theory, TVnn is a better indication of atmospheric turbulence in the boundary layer than TCnn or THnn, which are influenced by large scale eddies which affect the wind direction.

2.2 DATA ACQUISITION

The primary data acquisition system (DAS) is hosted in an industrial PC and was derived from an available weather acquisition system. The DAS accepts data from up to 32 serial ports. The DAS software operates under the Desqview multitasking environment. The DAS operating information is specified in a configuration file, which defines the message format and storage requirements for each serial channel.

Table 3. Data Acquisition System Channel Assignments, Lateral Positions, Parameter Names

Channel	CSDAS #1	CSDAS #2	CSDAS #3	CSDAS #4	CSDAS #5
0	ID=1	ID=2	ID=3	ID=4	ID=5
1	-650 ft C01	-300 ft C08	AC1	25 ft C17	350 ft C25
2	-650 ft V01	-300 ft V08	AC2	25ft V17	350 ft V25
3	-600 ft H01	-250 ft C09	0 ft C16	50 ft C18	400 ft C26
4	-600 ft C02	-250 ft V09	0 ft V16	50 ft V18	400 ft V26
5	-600 ft V02	-200 ft C10		75 ft C19	450 ft C27
6	-550 ft C03	-200 ft V10		75 ft V19	450 ft V27
7	-550 ft V03	-150 ft C11		100 ft C20	500 ft C28
8	-500 ft C04	-150 ft V11		100 ft V20	500 ft V28
9	-500 ft V04	-100 ft C12		150 ft C21	550 ft C29
10	-450 ft C05	-100 ft V12		150 ft V21	550 ft V29
11	-450 ft V05	-75 ft C13		200 ft C22	600 ft C30
12	-400 ft C06	-75 ft V13		200 ft V22	600 ft V30
13	-400 ft V06	-50 ft C14		250 ft C23	650 ft C31
14	-350 ft C07	-50 ft V14		250 ft V23	650 ft V31
15	-350 ft V07	-25 ft C15		300 ft C24	650 ft H31
16		-25 ft V15		300 ft V24	

2.2.1 Equipment Layout

The five CSDAS were located in three small shelters along the anemometer array to minimize cable lengths. The DAS was installed in a trailer and was one node in a Novell Netware computer network. The network permitted real-time analysis of the data from the anemometer array.

The primary purpose of the anemometer array was to track wake vortices generated by aircraft landing on Runway 27. The use of the same anemometers to sense ambient wind conditions was auxiliary to this main purpose. In fact, the wake vortices pose a data processing problem since they can corrupt the ambient wind data (see Section 3.2). The following three sections describe the various files recorded by the DAS. The second one (Section 2.2.3) was used for the wind analysis of this report.

2.2.2 Raw Wake Vortex Data Storage

The daily data file is named "WMmmDdd.Yyy," where the capital letters are fixed in the file name and mm is the month, dd is the day and yy is the year. This file stores one-minute data blocks and is saved on both the local DAS hard drive and the network fileserver. The configuration file used each day is copied to a file named "XMmmDdd.Yyy." This method of specifying the test configuration is useful for accommodating changes in the set up. Because of the amount of two-second averaged data, the complete WM file for one day contains 7.7 Mbytes. To reduce this file size by eliminating uninteresting data, two options were specified for the amount of data saved in the WM file: (a) all data, or (b) the minute before and four minutes after each aircraft arrival, which was detected by measuring aircraft noise near the middle of the main anemometer array.

2.2.3 Meteorological Data Storage

A secondary data acquisition program receives each one-minute data block as a mail message (under Desqview) from the primary data acquisition program. It saves the non-binary data as received, but processes the two-second binary data into one-minute means and standard deviations, which are stored as ASCII. The meteorological file is named DMmmDdd.Yyy and stores all one-minute data blocks for the day. It is recorded on both the local hard drive and the network fileserver. The configuration file for this file is named CMmmDdd.Yyy and was generated by manually editing one XMmmDdd.Yyy file rather than by automatic computer processing, since it was unchanged for the duration of the test.

2.2.4 Real-Time Analysis

The data collection program also outputs three files to the network fileserver that can be used for real-time analysis.

2.2.5 Clock Time

The data collection clock time was defined by the clock on the fileserver. This clock was set for Greenwich Mean Time (GMT). However, a PC's clock can drift significantly and the actual time was observed to err by as much as 20 minutes. This time drift was not documented, but could affect comparisons of wind data with surface observations (Section 2.4). The surface observations should, however, give a satisfactory indication of the general meteorological conditions for the detailed wind measurements.

2.3 KNOWN SENSOR FAILURES

There are three known sensor failures:

1. Although its performance was normal when installed, anemometer V21 became much less responsive on August 16, 1995 and deteriorated further on the following days to become virtually unresponsive, except to the highest wake vortex gusts.

2. The response of anemometer V28 was weak throughout the test.

3. On December 24, 1995 anemometer C09 stopped responding at 17:40.

2.4 SURFACE WEATHER OBSERVATIONS

The surface observations were obtained from another Volpe Center program and were not available for all times. The surface observations also use GMT.

3. DATA PROCESSING

3.1 DATA REDUCTION

The daily DM ASCII meteorological data files are processed into a binary performance file for each day; the file name is ONyymmdd. hhm, where yy is the year, mm is the month, dd is the day and hhm is the hour and tens of minutes for the first record in the file. The performance files are included on the CD ROM and can be plotted and analyzed using standardized software (see the Appendix). The files for each month were combined into a large performance file containing all the data for a month (not included on CD ROM). Database files were then generated by selecting parameters from the performance file for output, with date and time, into comma-separated ASCII files. The file formats provided are described in Chapter 4.

The complete daily WM data files (7.7 Mbytes) were converted directly to comma-separated ASCII format (26.5Mbytes). The conversion process retained all valid two-second messages and could therefore lead to some time anomalies if one CSDAS had more messages than another. The large size of these data files made validation impossible. They have not been analyzed.

3.2 WIND SELECTION

The estimate for the ambient wind and turbulence (standard deviation of vertical wind) was selected from one end of the array (pole 1 or pole 31). To avoid the influence of wake vortices on the measurement, the pole selected was upwind with respect to the crosswind. The crosswind direction was determined by taking the sign of the sum of the one-minute average crosswinds on the two ends of the array. The following Paradox v4.0 script was used for this calculation. It also generates integer values of crosswind, headwind and windspeed.

```
CLEARALL
EDIT "AUG95A"
SCAN
  CP=[C31]
  CN=[C01]
  IF (CP > -25) AND (CN > -25) THEN
    IF (CN+CP > 0) THEN
      [CROSS]=CN
      [HEAD]=[H01]
      [TURB]=[TV01]
    ELSE
      [CROSS]=CP
      [HEAD]=[H31]
      [TURB]=[TV31]
    ENDIF
    [SPEED]=SQRT([CROSS]*[CROSS]+[HEAD]*[HEAD])
    [CI]=ROUND([CROSS],0)
    [HI]=ROUND([HEAD],0)
    [SI]=ROUND([SPEED],0)
```

ENDIF
ENDSCAN
DO_IT!

3.3 RECORD VALIDATION

Outliers in the wind record were detected by generating histograms of integer headwind and crosswind. Any values not continuous with the distribution were eliminated (only for files named "mmmyyG.TXT," which are described in Table 9). The observed wind distributions are listed in the following section.

3.4 WIND DISTRIBUTIONS

This section presents the headwind and crosswind distributions for the ten months of the data set (Figures 1-10). In contrast to the JFK data[2], the crosswind distributions show no dip at zero crosswind (-0.5 to 0.5 m/s).

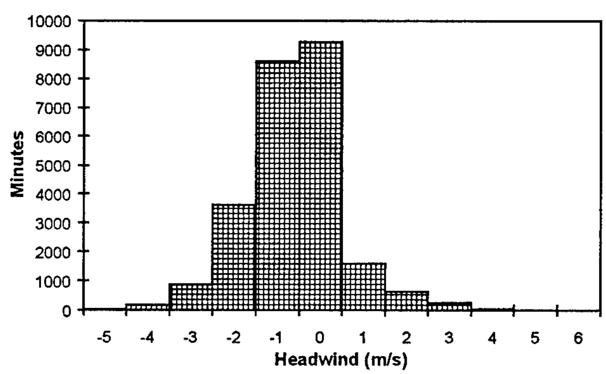


Figure 1. Headwind Distribution, Aug-95

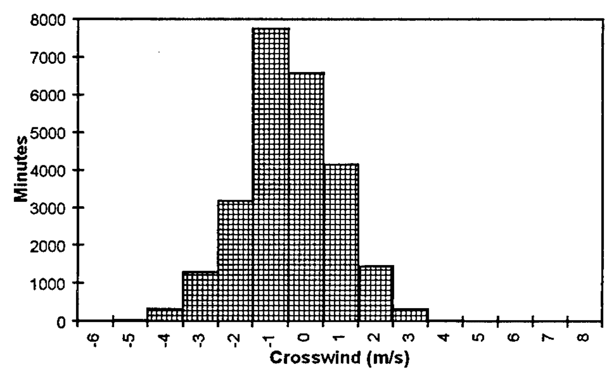


Figure 2. Crosswind Distribution, Aug-95

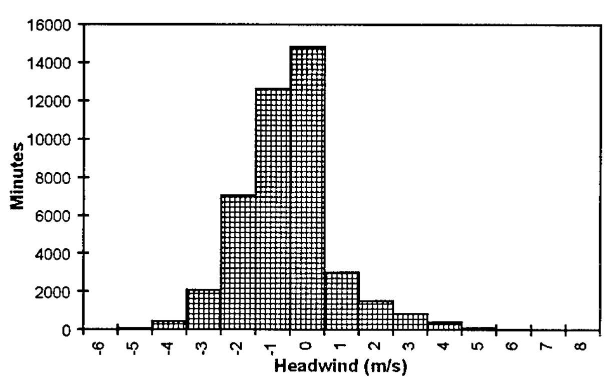


Figure 3. Headwind Distribution, Sep-95

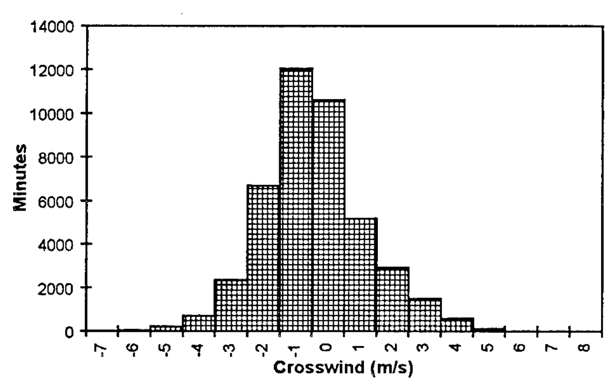


Figure 4. Crosswind Distribution, Sep-95

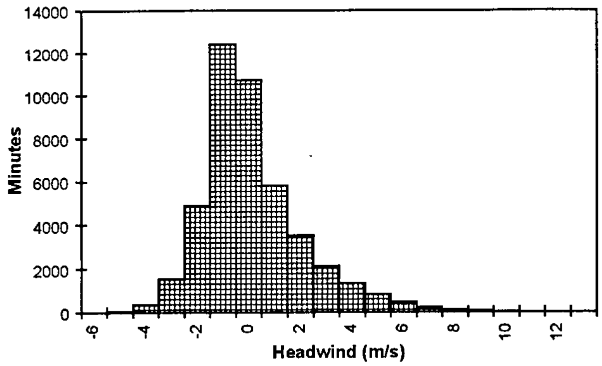


Figure 5. Headwind Distribution, Oct-95

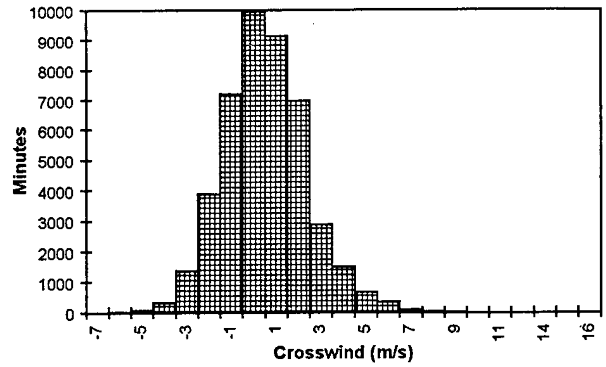


Figure 6. Crosswind Distribution, Oct-95

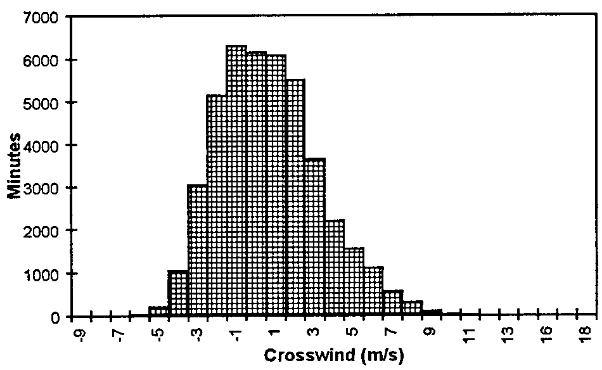


Figure 7. Crosswind Distribution, Nov-95

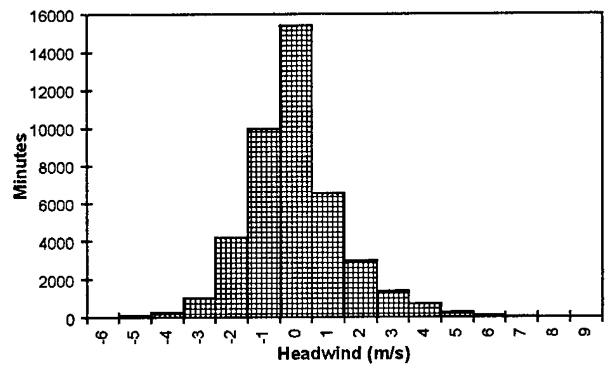


Figure 8. Headwind Distribution, Nov-95

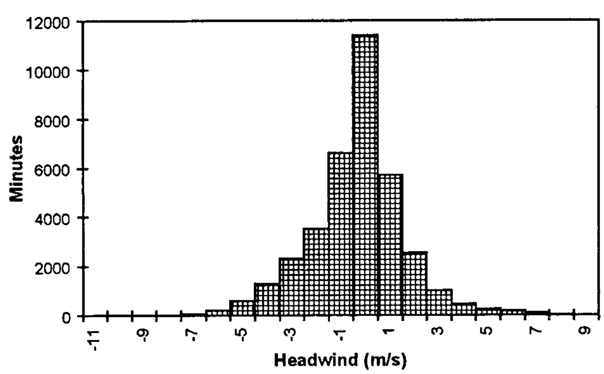


Figure 9. Headwind Distribution, Dec-95

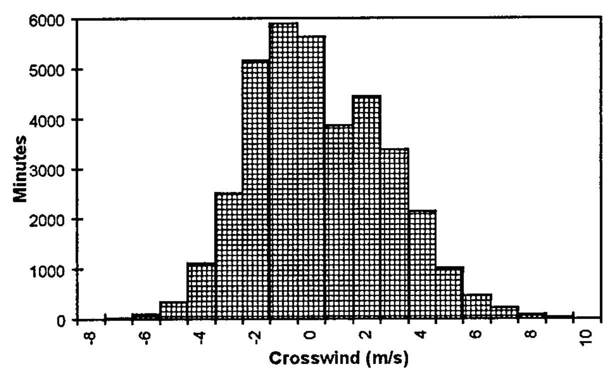


Figure 10. Crosswind Distribution, Dec-95

3.5 DATA AVAILABILITY

Table 4 shows the number of valid data minutes for each day of the data collection period. The total number of minutes in a day is 1440; the valid data minutes are always less than the 1440 because of the time taken at midnight to close the file for the previous day and open the new file for the next day.

Table 4 shows when data are missing. The only significant missing data are for August 20 and August 21. The data collection stopped on December 26.

Table 4. Minutes of Data per Day

Day	Aug-95	Sep-95	Oct-95	Nov-95	Dec-95
1		1435	1435	1433	1434
2		1435	1434	1433	1432
3		1435	1434	1435	1435
4		1435	1435	1434	1435
5		1435	1435	1433	1433
6		1435	1435	1435	1434
7		1435	1435	1434	1435
8		1434	1434	1434	1429
9		1435	1435	1432	1434
10		1435	1435	1435	1435
11		1435	1434	1425	1434
12		1435	1435	1433	1431
13		1435	1434	1434	1429
14	1417	1435	1435	1433	1432
15	1429	1435	1435	1432	1432
16	1431	1434	1434	1430	1435
17	1430	1435	1434	1433	1434
18	1435	1435	1435	1434	1435
19	1409	1435	1435	1434	1432
20	999	1435	1435	1433	1431
21	1231	1433	1434	1428	1428
22	1430	1434	1435	1433	1431
23	1435	1433	1432	1416	1430
24	1435	1435	1432	1433	1434
25	1435	1435	1433	1429	1429
26	1435	1435	1428	1434	588
27	1434	1435	1429	1430	
28	1435	1434	1433	1429	
29	1434	1435	1435	1430	
30	1435	1432	1435	1424	
31	1430		1433		
Total	25119	43039	44452	42945	36406
Days	31	30	31	30	31
Percent	56	100	100	99	82

Table 5. Surface Observations per Day

Day	Aug-95	Sep-95	Oct-95	Nov-95	Dec-95
1		24	24	33	23
2		21	26	26	24
3		24	27	25	24
4		24	21	16	26
5		13	26	17	35
6		22	23	30	28
7		22	24	21	21
8		25	7	23	26
9		28	22	19	25
10		28	24	24	23
11		23	24	29	24
12		23	15	24	22
13	1	24	10	23	17
14	24	22	24	27	26
15	18	23	24	20	25
16	25	22	20	26	27
17	26	35	21	24	27
18	20	24	23	17	25
19	26	18	24	25	36
20	24	26	19	22	24
21	22	26	24	24	27
22	16	28	23	14	20
23	21	24	19	35	23
24	23	24	22	23	23
25	23	26	24	22	25
26	24	24	22	24	23
27	21	23	28	19	22
28	24	24	27	26	19
29	24	24	22	27	20
30	26	23	25	21	18
31	23	1	22	1	32

3.6 SURFACE WEATHER OBSERVATIONS

The format for the surface weather observations is not particularly suitable for a database. Therefore, the observations were reformatted to clearly separate the different parameters. The final format is described in Section 4.4. Table 5 lists the number of observations for each day of the test period. Note that these observations have not been thoroughly validated and should be checked for duplicate records, etc. It is possible that some records from one day have also been included in another day; this problem clearly accounts for the observations for the 31st of September and November.

4. DATABASES

This chapter describes the databases distributed on CD ROM. All files are named by mmmyy where mmm is the month (e.g., Sep, Oct, etc.) and yy is the year (95). Missing data is signified by the value -99. 00. In addition to the ASCII data files described below, the CD ROM also contains the Borland Paradox v4.0 database tables (extension = DB), which may be useful to users of commercial relational database products.

4.1 COMPLETE FILES

Table 6 lists the 119 parameters in order for the complete comma-delimited ASCII databases. Not all of the parameters could be saved because of the limit of 114 parameters that are allowed by the performance file format. Some of the vertical wind parameter were omitted since they typically have zero mean value. The complete file name is "mmmyyALL.TXT," where the capital letters are fixed and the mmm is the three letter month abbreviation and yy is the year. Section 2.1.2 describes the parameter names. These files are generated from the recorded data directly, not exported from Paradox database tables. They, therefore, have not been filtered in any way for validity.

Table 6. List of Parameters in Files mmmyyALL.TXT

Year	C01	C17	TC01	TC17	TV01	TV17	V01
Month	C02	C18	TC02	TC18	TV02	TV18	V02
Day	C03	C19	TC03	TC19	TV03	TV19	V03
Hour	C04	C20	TC04	TC20	TV04	TV20	V06
Minute	C05	C21	TC05	TC21	TV05	TV21	V09
AC1	C06	C22	TC06	TC22	TV06	TV22	V12
AC2	C07	C23	TC07	TC23	TV07	TV23	V15
TAC1	C08	C24	TC08	TC24	TV08	TV24	V18
TAC2	C09	C25	TC09	TC25	TV09	TV25	V21
H01	C10	C26	TC10	TC26	TV10	TV26	V24
H31	C11	C27	TC11	TC27	TV11	TV27	V27
TH01	C12	C28	TC12	TC28	TV12	TV28	V30
TH31	C13	C29	TC13	TC29	TV13	TV29	V31
	C14	C30	TC14	TC30	TV14	TV30	
	C15	C31	TC15	TC31	TV15	TV31	
	C16		TC16		TV16		

4.2 PROCESSED FILES

Tables 7-9 show the formats of the three types of comma-delimited ASCII files exported from Paradox. In these tables the data are put in chronological order by keying the first five parameters (indicated by asterisk). The type of parameter is indicated as S for 16-bit signed integer and N for floating point number. The following paragraphs describe the files.

The mmmyy.TXT files (Table 7) are simplified versions of the complete files (Table 6).

The mmmyyA.TXT files (Table 8) have the following additional calculated parameters: crosswind, headwind, windspeed and turbulence from the upwind side of the runway (see Section 3.2 for algorithm) and the integer values: Ci, Hi and Si for Cross, Head and Speed, respectively.

The files mmmyyG.TXT (Table 9) contain selected fields from mmmyyA.TXT (Table 8). The records have been selected to have valid headwinds and crosswinds using the algorithm from Section 3.3.

Table 7. Format for Files mmmyy.TXT: Field Names and Types

Name	Type	Name	Type	Name	Type	Name	Type
Year	S*	C01	N	TV02	N	TV17	N
Month	S*	C31	N	TV03	N	TV18	N
Day	S*	TC01	N	TV04	N	TV19	N
Hour	S*	TC31	N	TV05	N	TV20	N
Minute	S*	V01	N	TV06	N	TV21	N
AC1	N	V31	N	TV07	N	TV22	N
AC2	N	TV01	N	TV08	N	TV23	N
TAC1	N	TV31	N	TV09	N	TV24	N
TAC2	N			TV10	N	TV25	N
H01	N			TV11	N	TV26	N
H31	N			TV12	N	TV27	N
TH01	N			TV13	N	TV28	N
TH31	N			TV14	N	TV29	N
				TV15	N	TV30	N
				TV16	N		

Table 8. Format for Files mmmyyA.TXT: Field Names and Types

Name	Type	Name	Type	Name	Type	Name	Type
Year	S*	TC01	N	TV11	N	TV26	N
Month	S*	TC31	N	TV12	N	TV27	N
Day	S*	V01	N	TV13	N	TV28	N
Hour	S*	V31	N	TV14	N	TV29	N
Minute	S*	TV01	N	TV15	N	TV30	N
AC1	N	TV31	N	TV16	N	Cross	N
AC2	N	TV02	N	TV17	N	Head	N
TAC1	N	TV03	N	TV18	N	Speed	N
TAC2	N	TV04	N	TV19	N	Turb	N
H01	N	TV05	N	TV20	N	Ci	S
H31	N	TV06	N	TV21	N	Hi	S
TH01	N	TV07	N	TV22	N	Si	S
TH31	N	TV08	N	TV23	N		
C01	N	TV09	N	TV24	N		
C31	N	TV10	N	TV25	N		

Table 9. Fields in File mmmyyG.TXT

Field Name	Field Type
Year	S*
Month	S*
Day	S*
Hour	S*
Minute	S*
Cross	N
Head	N
Speed	N
Turb	N
Ci	S
Hi	S
Si	S

4.3 TWO-SECOND DATA

Selected data files are provided in the two second data format mentioned in Section 3.1; the WM file name is changed to have an extension of PRN instead of the year. The file selection was based on available complete WM data files and the available space on the CD-ROM. The files are provided in self-extracting .EXE files to conserve CD ROM space.

The parameters in the two-second files are listed in Table 10. The format is essentially the same as that of the data collection, as listed in Table 3.

Table 10. List of Parameters in Files WMmmDdd.PRN

Header	CSDAS # 1	CSDAS #2	CSDAS #3	CDSAS #4	CSDAS #5
Year	Second	Second	Second	Second	Second
Month	"1"	"2"	"3"	"4"	"5"
Day	C01	C08	AC1	C17	C25
Hour	V01	V08	AC2	V17	V25
Minute	H01	C09	C16	C18	C26
	C02	V09	V16	V18	V26
	V02	C10	N/A	C19	C27
	C03	V10	N/A	V19	V27
	V03	C11	N/A	C20	C28
	C04	V11	N/A	V20	V28
	V04	C12	N/A	C21	C29
	C05	V12	N/A	V21	V29
	V05	C13	N/A	C22	C30
	C06	V13	N/A	V22	V30
	V06	C14	N/A	C23	C31
	C07	V14	N/A	V23	V31
	V07	C15	N/A	C24	H31
	NA/	V15	N/A	V24	N/A

4.4 SURFACE OBSERVATION FILES

The monthly Surface Aviation Observation (SAO) files are named "MEMyymm.TXT," where the capital letters are fixed and yy is the year and mm is the month. A sample record is shown, with the field numbers below:

MEM","SA",96,9,29,17,50,29.84,72,66, 28, 11,,,6,"",2,"SCT",24,"BKN",40,"OVC","E","TRW-","H"
(1) (2) (3)(4)(5)(6)(7) (8) (9)(10)(11)(12)(15)(17) (18) (19) (20) (21) (22) (23) (24) (25)

The fields in order are:

1. 'Site' - Site Code, where 'MEM' means Memphis International Airport, Memphis, TN
2. 'Rtype' - Report type:
   SA - Surface Aviation, issued hourly
   SP - Special Observation
   RS - Record Special observation, issued hourly but meets criterion for 'SP'.
3. 'Year'
4. 'Month'
5. 'Day'
6. 'Hour'

7. ‘Minute’
8. ‘Alts’ - Altimeter setting in inches Hg
9. 'Temp' - Temperature in degrees Fahrenheit
10. 'Dewpt' - Dewpoint in degrees Fahrenheit
11. 'Wdir' - Wind direction in degrees
12. 'Wspd' - Wind speed in knots
13. 'Wchar' - Wind character (gust) in knots. Blank if none is reported.
14. 'Paccum' - Precipitation accumulation in inches. This field is always blank because precipitation amounts are given in the remarks every 6 or 12 hours.
15. 'Hvis' - Horizontal visibility in miles
16. 'Obscur' - Sky obscuration (-X is partial obscuration, W is indeterminate ceiling, X is full obscuration). Blank if none.
17. 'Cbh1' - Cloud base height of layer 1 in hundreds of feet. Blank if 'Cc1' field is 'CLR'.
18. 'Cc1' - Cloud cover of layer 1 (CLR is clear, SCT is scattered, BKN is broken, OVC is overcast, minus sign in front means thin.)
19. 'Cbh2' - Cloud base height of layer 2 in hundreds of feet. Blank if 'Cc1'= CLR.
20. 'Cc2' - Cloud cover of layer 2. Blank if 'Cc1'= CLR.
21. 'Cbh3' - Cloud base height of layer 3 in hundreds of feet. Blank if 'Cc1'= CLR.
22. 'Cc3' - Cloud cover of layer 3. Blank if 'Cc1'= CLR.
23. 'ClgD' - Cloud base height determination method, for example, M = measured, E = Estimated. Blank if 'Cc1'= CLR.
24. 'Prwx' - Present weather. Most common are: R = rain, S = snow, L = drizzle, IP = sleet, A = hail. The letter 'T' before a precipitation type means thunderstorm. The letter 'Z' before a precipitation type (usually R or L) means freezing precipitation. A 'W' after the precipitation type means shower. Precipitation intensities are at the end of the field, with a '+' meaning heavy, a '-' meaning light and no symbol meaning moderate precipitation.
25. 'Ob2vis' - Obstruction to vision. Most common: F = fog, H = haze, BS = blowing snow

APPENDIX - SAMPLE STRIP CHARTS

The following strip charts were generated using the IBM-PC DOS program PSIGB. EXE, which operates on performance files (see Section 3.1) and generates HPGL/2 output on LPT1 that can be plotted on a Hewlett Packard LaserJet III or later model. The scale factors for the plots are set in the file SETUP. DAT. The sensors plotted are selected from an ASCII file of parameter names. The program, auxiliary files, parameter list files and performance files are in the PERFORM subdirectory of the CD ROM.

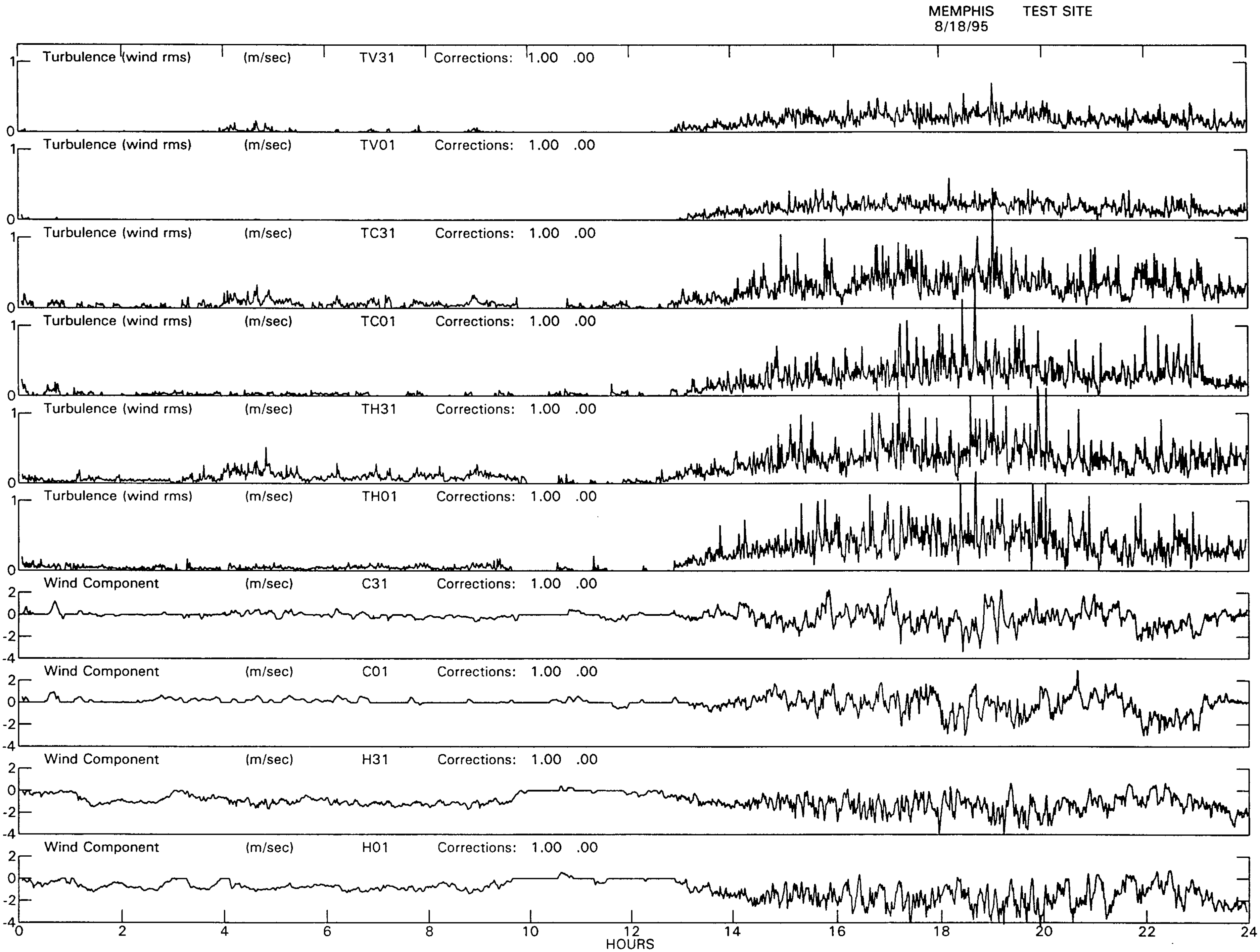
Five sample plots are attached; they used the parameter name files:

1. WINDTURB - This plot shows the wind data from the ends of the array.

2. CLOW, CHI - Crosswinds across the array (poles 1-20 for LO, poles 12-31 for HI). Note the opposite sign of the wake vortex crosswinds on opposite sides of C18 between 0300 and 0600 hours.

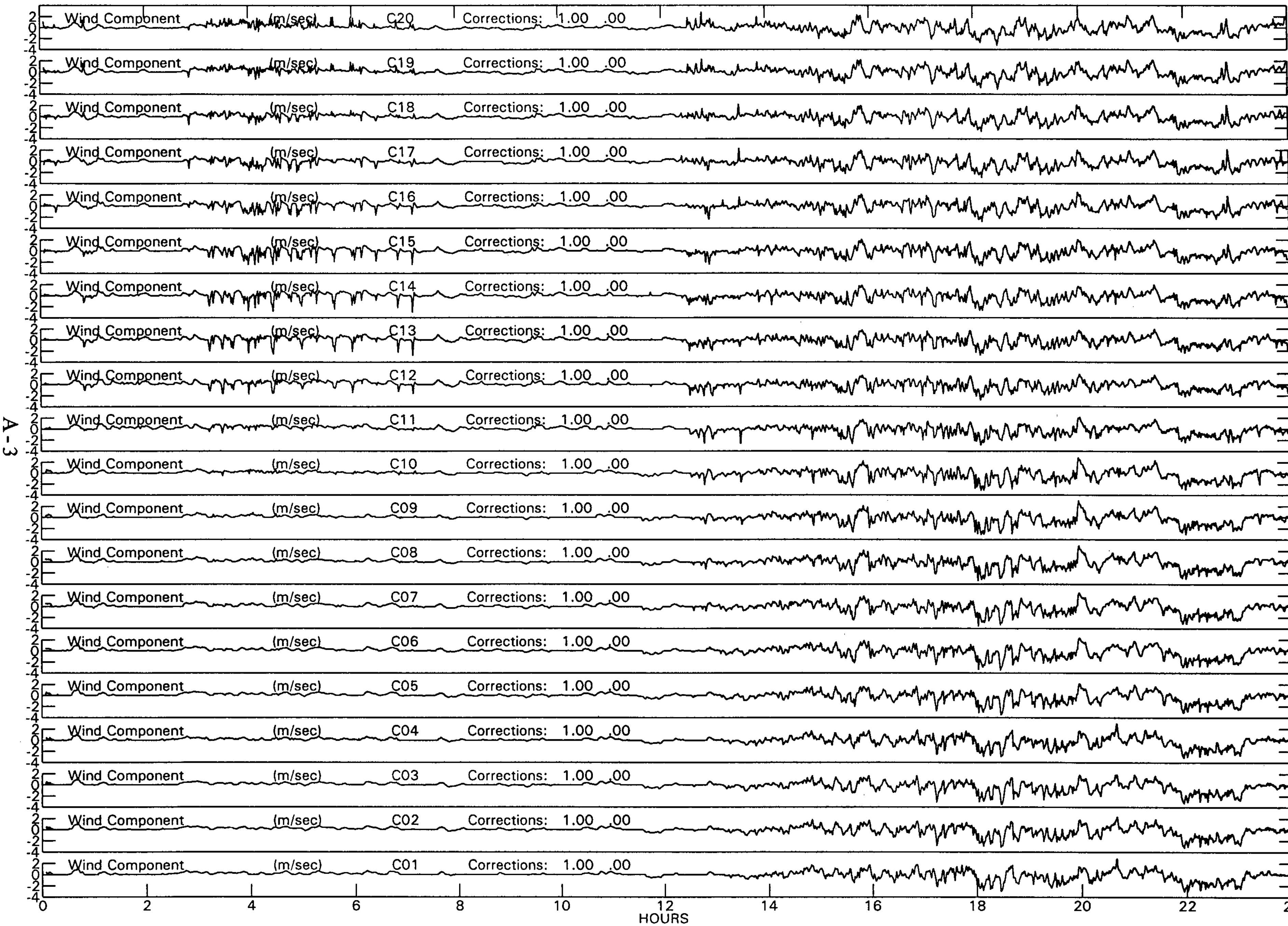
3. TVLOW, TVHI - Vertical wind turbulence across the array. Note positive vortex signatures from 0300 TO 0700 hours and also at other times. Note lower turbulence for lower poles (11 - 21) during the daytime (1400-2400 hours). Note weak response of TV28 and almost no response of TV21.

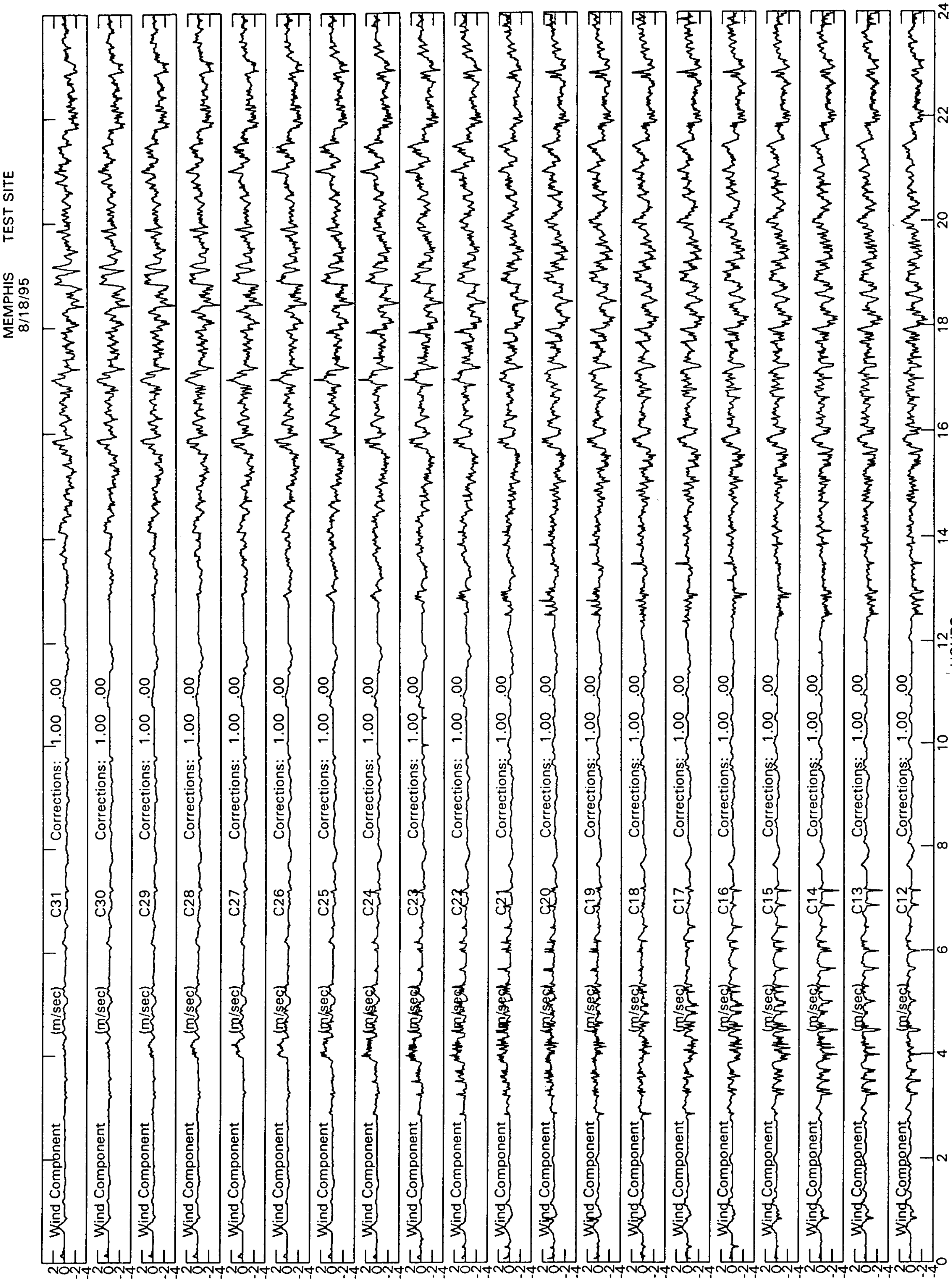
The spikes in the plots are caused by data transmission errors.



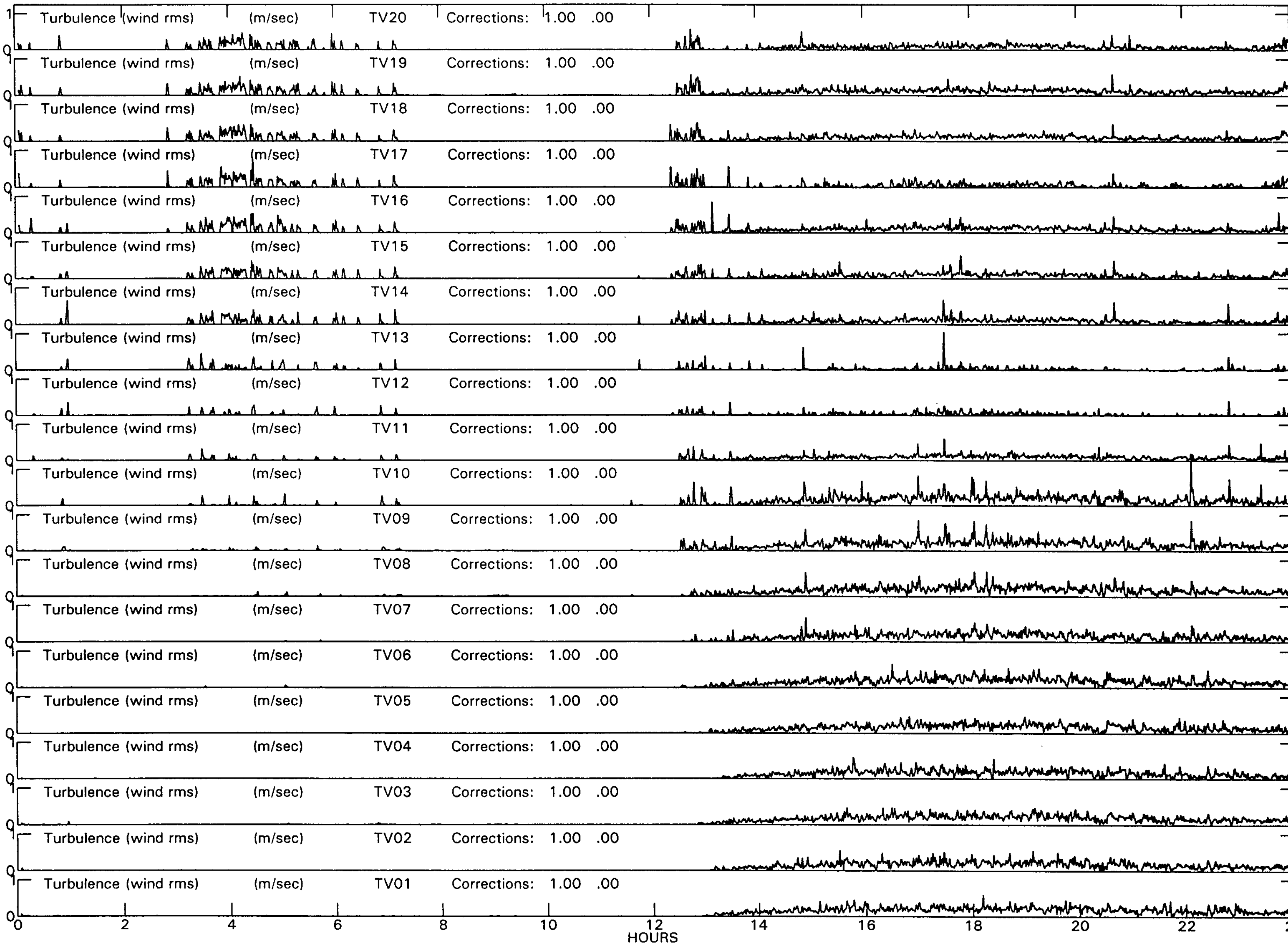
MEMPHIS TEST SITE
8/18/95
Turbulence (wind rms) (m/sec) TV31 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TV01 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TC31 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TC01 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TH31 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TH01 Corrections: 1.00 .00
Wind Component (m/sec) C31 Corrections: 1.00 .00
Wind Component (m/sec) C01 Corrections: 1.00 .00
Wind Component (m/sec) H31 Corrections: 1.00 .00
Wind Component (m/sec) H01 Corrections: 1.00 .00
HOURS

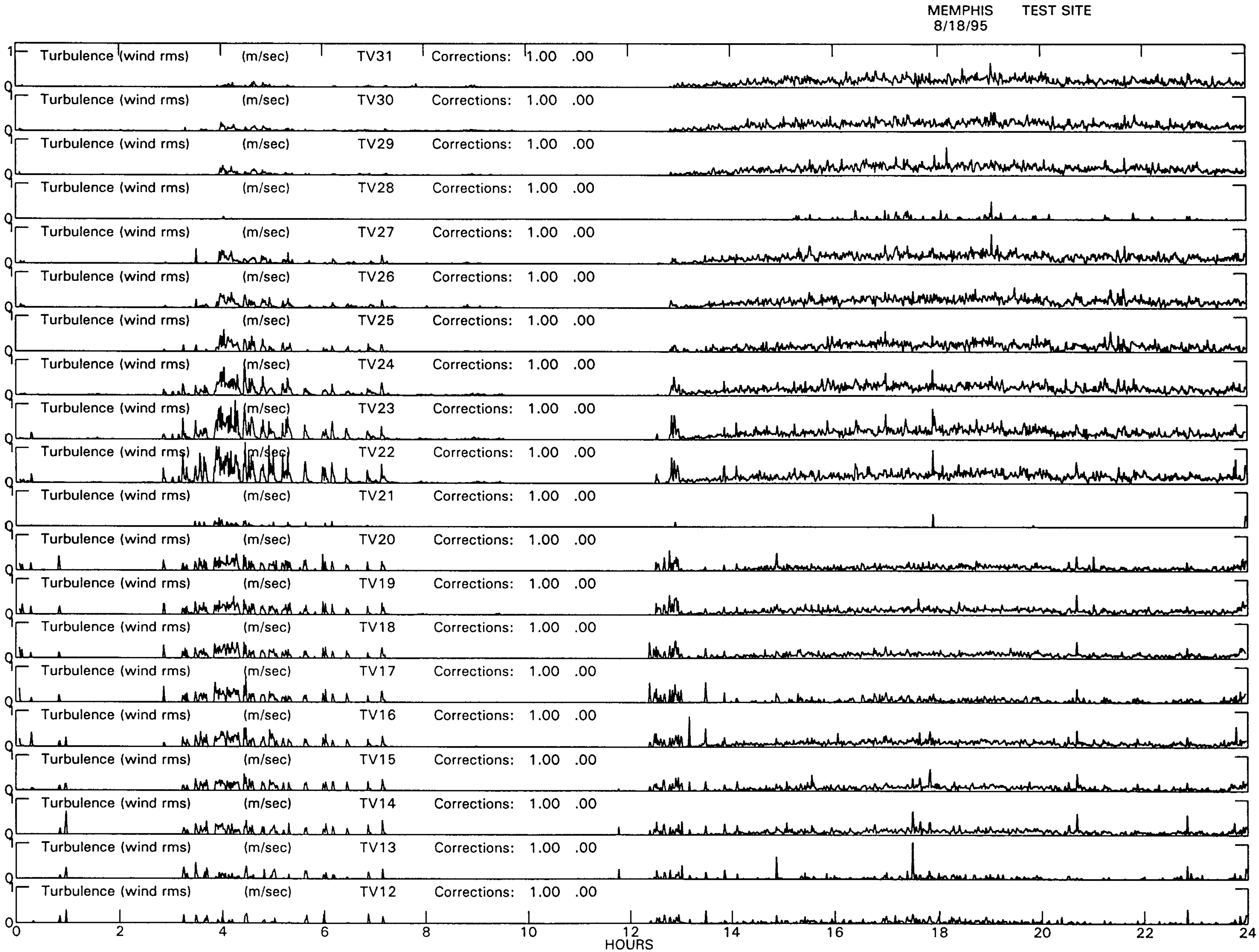
MEMPHIS TEST SITE
8/18/95




MEMPHIS TEST SITE
8/18/95
Wind Component (m/sec) C31 Corrections: 1.00 .00
Wind Component (m/sec) C30 Corrections: 1.00 .00
Wind Component (m/sec) C29 Corrections: 1.00 .00
Wind Component (m/sec) C28 Corrections: 1.00 .00
Wind Component (m/sec) C27 Corrections: 1.00 .00
Wind Component (m/sec) C26 Corrections: 1.00 .00
Wind Component (m/sec) C25 Corrections: 1.00 .00
Wind Component (m/sec) C24 Corrections: 1.00 .00
Wind Component (m/sec) C23 Corrections: 1.00 .00
Wind Component (m/sec) C22 Corrections: 1.00 .00
Wind Component (m/sec) C21 Corrections: 1.00 .00
Wind Component (m/sec) C20 Corrections: 1.00 .00
Wind Component (m/sec) C19 Corrections: 1.00 .00
Wind Component (m/sec) C18 Corrections: 1.00 .00
Wind Component (m/sec) C17 Corrections: 1.00 .00
Wind Component (m/sec) C16 Corrections: 1.00 .00
Wind Component (m/sec) C15 Corrections: 1.00 .00
Wind Component (m/sec) C14 Corrections: 1.00 .00
Wind Component (m/sec) C13 Corrections: 1.00 .00
Wind Component (m/sec) C12 Corrections: 1.00 .00
2 0 -2 -4
0 2 4 6 8 10 12 14 16 18 20 22 24
HOURS

MEMPHIS TEST SITE
8/18/95




MEMPHIS TEST SITE
8/18/95
Turbulence (wind rms) (m/sec) TV31 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TV30 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TV29 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TV28 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TV27 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TV26 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TV25 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TV24 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TV23 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TV22 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TV21 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TV20 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TV19 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TV18 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TV17 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TV16 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TV15 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TV14 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TV13 Corrections: 1.00 .00
Turbulence (wind rms) (m/sec) TV12 Corrections: 1.00 .00
1
0
0 2 4 6 8 10 12 14 16 18 20 22 24
HOURS

REFERENCES

1. Sullivan, T. E. and Burnham, D. C., "Ground Wind Sensing System Calibration Tests," Report No. FAA-RD-80-13, February 1980, Transportation Systems Center, Cambridge, MA.

2. Burnham, D.C. and Abramson, S., "Wind Data from Kennedy Airport," Report No. DOT/FAA/ND-97-3, May 1997, DOT Volpe National Transportation Systems Center, Cambridge, MA.

3. Abramson, S. and Burnham, D. C., "Ground-Based Anemometer Measurements of Wake Vortices from Landing Aircraft at Airports," AGARD-CP-584 Conference Proceedings, The Characterization & Modification of Wakes from Lifting Vehicles in Fluids, 20-23 May 1996, Trondheim, Norway, November 1996, pp. 13-(1-7).